The Institute of Physics

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The Bulletin is published by The Institute of Physics for circulation to its members ; copies should not be placed in libraries.

Notices to Members

The New Bulletin

The Editor of the Bulletin (Mr. Clarke) in consultation with the printer (Mr. R. Milner) has given considerable thought to the new layout and design now presented to members. The result, of course, has had to satisfy certain boundary conditions, notably a budget and the rising cost of all the commodities which go into this production.

It is intended to change the colour of the cover every year and perhaps to make other minor changes in the light of comments received.

H.R.L.

Payment of Annual Fees

Members who do not pay their fees by Banker's Order are again asked to co-operate in reducing the cost and labour of collecting fees by using the form printed on page v.

The Institute's 1956 Budget

At its meeting on November 15 last the Board approved the Institute's Budget for 1956, submitted by the Treasurer on behalf of the Finance and General Purposes Committee. The estimated income is £55,500 compared with an estimate of £50,300 in 1955. The amount expected from the sale of journals and other publications is £33,100 (£27,800 in 1955) ; the increase should come mainly from the increase in the retail price of the *Journal of Scientific Instruments* and from purchases of journals by Fellows and Associates. Advertisements in the journals are expected to yield at least £9,000 after

deduction of agents' commission. Members' subscription fees are budgeted to yield £13,200, an increase of £600.

The main items of expenditure are on production of publications and staff salaries. For printing and distributing publications an expenditure of £19,900 is authorized, this being a reduction of £2,000 on the previous year ; it has been necessary to provide for an expected substantial rise in the cost of postage and in printing prices but fewer and smaller books are planned for publication in 1956 than in 1955. Salaries, wages, insurance and superannuation will cost £16,000 (£14,200 in 1955) ; half of this sum is attributable to production of publications.

The cost of the House, including cleaning and caretaking, is estimated at £5,500. The vote for grants to Branches and Groups has been increased from £1,800 to £2,200, exclusive of the cost of this work borne on other accounts such as salaries and the House.

Allowance has been made in all items for rising costs, including the substantial increase in postage and telephone charges recently announced. After allowing for depreciation and for the annual premium of £985 on the policy that will provide the Institute with £40,000 when the lease of the House expires, the final budgeted surplus is £815.

Diplomas in Technology

The first five names of members of the new National Council for Diplomas in Technology, appointed by the Minister of Education, include that of Dr. Willis Jackson, a Fellow of the Institute. The setting up of the new Council was recommended by the National Advisory Council on Education for Industry and Commerce and the Minister has appointed Lord Hives, chairman of Rolls-Royce Ltd., to be its first Chairman.

The Council will have the advice of two Boards of Studies. To the Board of Studies in Technologies other than Engineering, The Institute of Physics has been invited to appoint a representative and has nominated Professor F. A. Vick (*Vice-President*). Two other Fellows of the Institute also serve on this Board ; Dr. J. Topping has been nominated by the Association of Principals of Technical Institutes and the Association of Teachers in Technical Institutes and Mr. G. A. Whipple has been appointed by the Minister of Education. At the first meeting of this Board of Studies, Dr. Topping was elected Vice-Chairman and this post gives him a seat on the National Council.

Two Fellows also serve on the Board of Studies in Engineering. Mr. H. S. Barlow has been nominated by the Associations of Principals and Teachers in Technical Institutions ; Dr. T. E. Allibone has been appointed by the Minister.

Dispatch of Publications

With the new position whereby Fellows and Associates of the Institute no longer receive one of the Institute's monthly scientific Journals without additional charge, new dispatch arrangements are being made. The Bulletin will no longer be wrapped with the Journals sent to members but all copies will be separately posted.

Properties of Materials at High Rates of Strain

The Institution of Mechanical Engineers is arranging a conference on the Properties of Materials at High Rates of Strain to take place in March, 1957. It is expected that the papers will be grouped under six main subject headings as follows :—(*a*) Metal Physics, (*b*) Experimental Techniques, (*c*) Wave Propagation Strain-Rate Effects on Small Strains, (*d*) Metal Working, (*e*) Non-Metals, (*f*) Basic Properties.

The latest date for submission of scripts will be September 30, 1956, but authors should notify the Secretary of the Institution of Mechanical Engineers as early as possible of their intention to submit a paper.

International Congress of Applied Mechanics

The ninth International Congress of Applied Mechanics will take place at the University of Brussels from September 5 to 13, 1956. Full particulars and registration forms may be obtained from the Assistant Secretary of the Royal Society, Burlington House, London, W.1.

Vol. 7, January, 1956

Patents for Inventions

By F. W. G. GREENER, B.Sc., A.Inst.P., F.C.I.P.A.

NATIONAL SECURITY, welfare and progress depend alike upon the continuing application of scientific and technical knowledge to adapt and improve industrial products and processes. In recognition of this fact legal provisions exist, in all but the most primitive territories of the world, to encourage the development and exploitation of inventions resulting from the application of scientific discoveries to industry, and it is thought that the brief outline of these provisions, and the manner in which they operate, set out in this short article may be of interest to members engaged in, or setting out on, a career in physics.

The basis of all such legal arrangements is to grant to an inventor a monopoly in the exploitation of his invention for a limited period, in return for a full disclosure of all necessary details of the invention so that, upon termination of his monopoly, the public will be able to make and use the invention. The monopoly rights are granted in Letters Patent after the inventor has set out a full description of his invention, in prescribed manner, in a patent specification, and the legal provisions are known as Patent Law.

It is interesting to remember that the current concern about the establishment of monopolies in the commercial field had a counterpart in the outcry raised regarding the grant of monopolies in a legal sense nearly 400 years ago. The impecunious Tudor monarchs, and especially Queen Elizabeth I, made a habit of granting monopolies to favourites, no doubt in return for financial and other returns. Many of these monopolies were a great handicap to individual freedom in developing industry and commerce, such as the monopoly granted to a foreigner to export Cornish tin, and another to foreign weavers for the manufacture of textiles. As the result of public complaint against the scandalous nature of these grants Parliament, after several unsuccessful attempts to introduce laws controlling the evil, eventually in 1623 passed the Statute of Monopolies which declared that all monopolies should henceforth be void and of no legal effect. One proviso was, however, introduced, namely that the aforesaid declaration should not apply to the grant of monopolies, for a limited term, in respect of "the sole working or making of any manner of new manufacture within this realm, to the true and first inventor and inventors of such manufactures which others at the time of making such letters patent and grants shall not use, so as also they be not contrary to the law or mischievous to the State, by raising prices of commodities at home, or hurt of trade, or generally inconvenient."

This statement is the basis of patent legislation in Great Britain and in many other countries. It is important to note that:

(*a*) the invention must be related to manufactures, i.e. to the article or material manufactured, and/or to the method or process employed to produce it. Thus a patent will not be granted for a system of backing horses, or rules for playing a game with a known pack of cards, or a manner of arranging papers for convenience in storing or reference.

(*b*) The manner of manufacture must be new. This means that the invention must not be publicly known, e.g. by non-confidential publication of a description in a journal or the like, prior to the date when patent protection is sought. It follows from this that ideally no details of any invention should be disclosed by the inventor to any other person until formal steps have been taken in applying for a patent.

Other features of, and developments from this section of the Statute of Monopolies will appear briefly below, but it will perhaps be more convenient first to outline the modern procedure to secure grant of a British patent, as now governed by the Patents Act, 1949, and the Patents Rules which accompany that Act.

Application for a patent may be made by any person, British, foreign or stateless, male or female, of any age, who claims to be the true and first inventor of the invention (or to have acquired rights to be an applicant from the true and first inventor), by completing a prescribed form, upon which must be impressed an Inland Revenue stamp for £1, and filing it by hand or by post, at the Patent Office in London. This form must be accompanied either by a provisional specification or a complete specification of the invention. If a provisional specification is filed with the application form, a complete specification must be filed within the succeeding twelve months (or, upon payment of an extension fee, during the three months following expiry of the twelve months period allowed). If a complete specification has not been filed within the fifteen months permitted, the application becomes void. A provisional specification sets out the basic ideas or principles of the invention, and, if drawings of the invention are possible, they may or may not be included. A complete specification (which must be impressed with a £4 stamp), in addition to setting out the basic ideas and principles, must also describe in full detail at least one form of the invention ; and drawings, where applicable, are nearly always required. The complete specification must terminate with one or more claims specifying clearly and concisely what combination of features the applicant believes to be novel and wishes to be able to prevent competitors from making, using or selling without his consent. The specifications are legal documents and their wording (especially the wording of the claims in the complete specification) determines the scope of protection ultimately afforded by any patent granted on the application. It is therefore wise to call in professional skill and experience in preparing these documents.

After the complete specification has been filed all the papers relating to the application are passed to an Examiner in the Patent Office who considers them in order to make sure that they comply with the Act and the Rules. In addition to examining the papers in order to ensure that they are formally in order, e.g. clear and concise, the Examiner also carries out a search through the specifications of British patents issued during the last fifty years, and U.S. patents issued since 1932, with a view to tracing any such specifications which describe a similar prior invention embodying some or all of the features claimed to be novel in respect of the invention described in the application. In due course the Examiner reports the result of his work to the applicant, or his Patent Agent, who then proceeds to amend the documents so as to overcome the Examiner's objections. In particular the claims in the complete specification are reworded so that the combination of features claimed is different from any combination of features described in any one of prior specifications reported by the Examiner. When these amended papers are refiled the Examiner again considers them and may again return them to the applicant with further objections (e.g. that the amendments are insufficient to overcome his original objections, or that as a result of a further search he has found other relevant prior specifications), to meet which the applicant is requested to make further amendments. This see-saw operation may be repeated several times, and at any time it is possible to interview the Examiner in order to argue the matter with him, and, if deadlock is reached, to ask for the matter to be argued before, and decided by, a senior officer, at a discussion known as a hearing.

When, in due course, the papers are in a condition satisfactory to the Examiner, they are passed to "acceptance." Prior to acceptance the papers are secret in the Patent Office and inaccessible to the public, who at that time can learn only the number

allocated to an application, the date when it was filed, the name of the applicant and the title of the application from a weekly publication, the *Official Journal (Patents)*. After acceptance the provisional and complete specifications, with drawings, if any, are printed and published, and copies can be purchased by the public.

For three months from the date of publication of the specification it is possible for a member of the public to file a notice of opposition to the grant of a patent on that specification. Various grounds for opposition are laid down in the Act, including evidence that the invention claimed was wholly or in part known to the public in a printed publication available in this country before the date when the patent application was filed ; and that the applicant " obtained," i.e. improperly learned of or took over, the invention from the opponent, who, in fact, originated the invention. Except in cases of " obtaining " it is generally possible for the applicant and the opponent to agree between themselves as to amendment of the specification which will satisfy the opponent and lead to withdrawal of his opposition. Where such agreement is reached an Examiner considers all the papers, including the grounds for opposition, and decides whether or not the proposed amendments are permissible and satisfactory, especially in so far as they purport to overcome the objections on which the opposition was based. If he agrees, the opposition is closed : if he is not satisfied further opportunity is given to the applicant (subject to the opponent's views) for amendment of the specification in order to reach a satisfactory conclusion. If amicable settlement of this kind between the opponent, the applicant and the Examiner is not possible, the opposition is considered at a hearing before the Comptroller of Patents, or one of his senior officers, at which the opponent and applicant present their arguments and evidence, whereafter the Hearing Officer decides whether or not a patent is to be granted, and whether or not amendment of the specification is necessary (and in what way) before a patent will be granted. In all these proceedings the Hearing Officer considers not only the rights of the opponent and applicant, but also the rights of the public in order to ensure as far as possible that no patent enforceable against the public shall improperly be granted, and thus illegally restrict public freedom.

In connection with all the above described procedure at the Patent Office provision is made whereby an applicant or opponent dissatisfied with a decision against him can appeal to the Patents Appeal Tribunal (a judge of the High Court), by whom the matter or matters in dispute (whether between applicant and Examiner, or applicant and opponent) are reconsidered, and a final judgement given.

After an opposition has been settled in favour of the applicant for a patent, or, if no opposition is raised, after expiry of the three months period of opposition allowed, the applicant is finally required to pay a sealing fee of £3 whereafter the patent is granted, formal Letters Patent being sealed and issued to him.

It is not to be imagined that when the patent is granted the troubles and responsibilities of the patentee have come to an end. It is true that from that date he is in possession of a document purporting to give him a legal right to prevent competitors from making, using or selling any device within the scope of one or more of the claims in his patent specification, but he must take the necessary legal action to enforce that right against the " infringer " in the High Court. In this connection it is pertinent to point out that proceedings by the Patent Office are mainly of an administrative nature to ensure that the patent application complies with all the more formal requirements laid down by the Act, whereas a Court considers the matter much more widely and deeply. In particular the Patent Office is not primarily concerned with whether or not any patent, if granted, will be valid i.e. will be properly granted and enforceable. For example an invention described in a patent specification may consist in a well-known device but incorporating a very small modification in construction. Provided

the specification makes quite clear that the novelty of the invention resides only in that modification, however small and apparently unimportant, a patent will be granted on the application. If, however, such a specification comes before a Court, e.g. in an infringement action, the Court will consider whether or not the minute difference relied upon really shows sufficient inventive ingenuity to support a patent, or is merely a well-known or obvious variation which required no inventive inspiration to introduce. To uphold the patent the Court is satisfied even if very little inventive ingenuity can be seen, but if there is none the Court will decide that the patent has been improperly granted, and will declare it invalid. The patent is then revoked.

The grounds upon which a patent may be found invalid by a Court include those referred to above as a basis for opposition prior to the grant of a patent, and others, e.g. that the invention claimed does not achieve the result, or provide the advantages, promised of it in the specification ; or that the patentee has withheld vital information or has not described in the specification the best way of carrying out the invention. These grounds can be set up in defence by any party accused of infringing the patent, or can be raised by any interested party who can apply to Court for revocation of a patent, which he alleges to be invalid, and which appears to threaten his intended activities.

When granted the patent remains in force for a period of four years from the date of filing of the complete specification. To keep it in force for a longer period (up to the maximum normal period of 16 years) the patentee is required to pay yearly renewal fees prior to the commencement of each succeeding year, and the amount due (which may be regarded as a form of tax) increases year by year, since the value of the patent clearly increases year by year as the invention becomes more widely known and adopted. If at any time the renewal fee due is not paid, the patent lapses and the invention becomes freely available to the public. Provision is, however, made for reinstatement of a patent which lapses because failure to pay a renewal fee arose from accident or inadvertence.

Another responsibility which falls upon a patentee is to take care, as far as he can, that his patent rights are employed to encourage or foster industry and are not abused. The patent is granted with the primary object of fostering industry in this country, and if the patentee fails to take steps to manufacture the patented invention and to make it available to the public, either by his own efforts or through one or more licensees, it is possible for a third party to apply to the Patent Office for a compulsory licence under the patent. Such action may be commenced three years or more after the patent is granted, and may be based not only on the ground that the patent is not being " worked," i.e. the invention is not being made and sold, but also that the patent is being used in an illegally obstructive manner (e.g. that the patentee will not grant a licence on reasonable terms).

So far we have been discussing the law in this country, but the position in foreign countries must not be overlooked. Patent laws exist in all industrialized countries in the world, and while they have the common object of encouraging the introduction of inventions, and industry arising therefrom, in each of the countries concerned, in return for the grant of a monopoly (or, in Russia and some satellite countries, the possibility of an *ex gratia* award, and the granting of a laudatory certificate) to the inventor or his nominee, the legal provisions, and the procedure involved vary widely from country to country. In most countries of the British Commonwealth the law follows quite closely the British law discussed above. Elsewhere procedure differs. In some countries, e.g. France, there is little or no examination of an application by an Examiner, and patents are granted almost automatically. Questions dealt with in this country by the Patent Office Examiner (e.g. whether or not the invention claimed is novel) do not arise for discussion in those

countries until the patent comes before a Court during a dispute. In other countries the Examiner has powers in connection with questions which are, in this country, normally reserved for settlement by a Court (e.g. in U.S.A. and in Holland the Examiner is empowered to reject an application on the ground that although the invention claimed clearly embodies one or more features of difference from any similar previously known device, the difference is obvious and not sufficiently meritorious to justify the grant of a patent). As a result of these variations in the patent laws of different countries, considerable variety and complexity arises in securing patents in several different countries for the same invention.

A provision of the utmost importance from the inventor's point of view is the International Convention for the Protection of Industrial Property, which relates *inter alia* to patents for inventions. This Convention is subscribed to by practically all the important countries in the world except Russia, and the South American countries, excluding Brazil. It provides that after a patent application has been filed in any one of the member countries and accorded the priority date of that filing, the applicant can file applications for patents for the same invention in any or all of the other member countries at any time during the succeeding twelve months and these additional applications will be accorded the priority date of the original application. The importance of this provision will be apparent when it is remembered that the validity of a patent depends *inter alia* upon the invention claimed being novel, i.e. unknown in the country concerned, at the date accorded to the patent application. Supposing that a patent application has been filed in Great Britain on June 1, 1955, the inventor may then wish to explore the possibility of obtaining patents in, say, France and Germany with a view to arranging for exploitation of the invention in those countries. For this latter purpose it would almost certainly be necessary for him to disclose the invention to French and German manufacturers.

If the date of protection in France or Germany could only be established by the actual filing of patent applications in those countries it would be essential for the inventor to file such applications before disclosing the invention to the French or German manufacturers, since the invention would no longer be novel (and therefore patentable) in applications filed at a date subsequent to such disclosure. If the inventor's negotiations proved fruitless all this trouble and expense would be wasted.

The above-mentioned provisions of the International Convention eliminate this difficulty. After filing the British Application on June 1, 1955, the inventor can safely disclose the invention to manufacturers anywhere abroad, knowing that any applications filed in foreign countries on or before June 1, 1956, will be accorded the priority date of June 1, 1955, which will be earlier than the date of disclosure to the foreign manufacturers. The novelty of the invention in the countries concerned will not therefore be affected in any way by his disclosure of the invention to the foreign manufacturers before filing patent applications in those countries. Thus the inventor has twelve months during which he can safely make enquiries before deciding whether or not to incur the trouble and expense of filing applications for patents abroad.

In passing it should perhaps be remarked that patents are a form of property, and like all other forms of property can be sold, licensed on agreed terms, mortgaged or bequeathed. It is, of course, by sale or licence that an inventor lacking the necessary manufacturing facilities hopes to secure a financial return, and in this connection it should not be overlooked that, under the International Convention referred to above, an applicant for a patent, immediately his application is filed in this country, has acquired potential rights abroad which he can forthwith take steps to dispose of, as well as having set up potential rights in this country.

Finally it may be appropriate to mention the professional services available to inventors in securing patents. These services are provided by individuals known as Patent

Agents, whose names and addresses are set out in a Register set up by law. No person may refer to himself as a Patent Agent (or, with the exception of solicitors, carry out any services for others in obtaining patents) who has not undergone specified training and passed specified examinations held yearly in accordance with law. Among other duties a Patent Agent will advise his clients whether or not an invention is novel and patentable, and will prepare the necessary papers, and carry out all details of filing and prosecuting applications, in order to secure patents anywhere in the world. He will also remind his clients upon formal questions such as renewing and "working" patents by the due dates, and will advise on questions of validity and infringement when legal proceedings are contemplated. Alternatively he will advise a client who proposes to make and sell a new article whether or not, by so doing, he is likely to render himself liable to legal proceedings under any patents held by third parties and still in force in any country. Where legal proceedings are taken, the Patent Agent is normally responsible for obtaining and supplying the documentary and other material required in the action by solicitor and counsel. In order to provide these services effectively a Patent Agent must have broad general knowledge in technical fields, in order that he can understand and discuss the widely different inventions brought to him by his various clients, as well as extensive knowledge of patent law and procedure in the countries throughout the world in which his clients desire protection. While it is true that an inventor can secure patents without the assistance of a Patent Agent, it may be thought that, in view of the experience provided, it might be a false economy not to employ a Patent Agent's services when success or failure may depend upon proper and effective action, in order both to secure and exploit protection.

Vol. 7, January, 1956

The British Coal Utilization Research Association

By R. L. BROWN, M.A., F.Inst.P.

(*Director of Basic Research Laboratories*)

FOR THE STUDY of industrial processes, apparatus and instruments are required. This provides the immediate task of the physicist in a Research Association. He is asked to do such things as to combine a counter with a microscope to make an automatized particle sizer : or to carry out detailed improvements in X-ray cameras to aid the study of minerals in coal. He is also asked to devise simple techniques. Thus, to study the breakage of coal some progress can be made by dropping lumps on to an iron plate and measuring the size distribution of the broken material. The research physicist must be versatile, his activities ranging from the applications of simple reasoning to attempted explanations of natural phenomena in terms of mathematical formulae. As an example of the former, he deduces that by restricting the area of the chimney throat the amount of air drawn through a room could be controlled and the performance of the fire improved, and that by placing a cowling round the fire to provide convective in addition to radiative heat the efficiency could be further improved. After considerable development work, a design of fire deriving from these ideas is now available commercially (Figure 1). Again, he notes that balling occurs when coal slurries are stirred, and realizes that the principle involved could be utilized in pellet making. Accordingly, he devises an oscillating tray with a ridged surface over which slurry is rolled, and thus obtains pellets, which can be more easily handled than the original slurry. Here the physicist appears in the guise of a mechanical engineer. In his more academic activities the research physicist may elaborate new ideas, such as a theory of the settling of dense suspensions of solids in fluids, or he might analyse complex breakage processes by applying matrix methods.

In industrial research, the value of the physicist's contribution depends on the inspiration and ingenuity with which he applies his fundamental knowledge and trained powers of observation to the solution of technical problems. Progress accrues from this interplay of fundamental knowledge and practical necessity. Industrial research, particularly in a traditional industry such as the coal industry, may be likened to the laborious solution of a cross-word puzzle. Thus, in coal utilization research physical, chemical and engineering problems are interwoven and demand for their solution closely integrated team work. The initiative of each individual must be deployed in such a way as to make advances possible. The problems investigated at the British Coal Utilization Research Association fall into three natural groups :—

(1) physical, concerning mass and heat transfer,

(2) chemical, concerning the constituents of coal and their reactions,

(3) engineering, concerning the design and fabrication of plant that will work.

To appreciate the pattern of research in the B.C.U.R.A., it must be understood that there are certain key researches, just as in solving a cross-word puzzle there are certain key words, which greatly simplify the task.

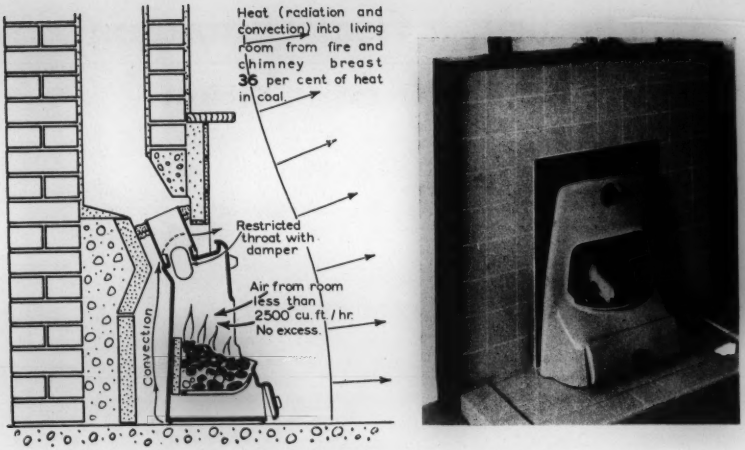
Heat (radiation and convection) into living room from fire and chimney breast
36 per cent of heat in coal.
Restricted throat with damper
Air from room less than 2500 cu. ft. / hr. No excess.
Convection

FIG. 1. *Convector free-standing open fire with restricted throat. (Giving increased comfort plus one-fifth saving of fuel as compared with conventional open fire.)*

The present pattern is given in Figure 2. The emphasis swings first one way and then another as new knowledge is gained, but the general pattern changes only slowly. The centre circle indicates the two main themes of work, coal as fuel and coal as material : in the outermost annulus are given the research departments of the Association. The problems currently under investigation are shown in the tags outside the diagram. It will be seen that the research departments keep the balance between the outward surge of the developing themes of work and the inward pressure of the practical needs of industry.

Physics of mass and heat transfer is encountered everywhere. The chemistry of coal is of obvious significance in the study of coal constitution. Chemistry is encountered also in combustion problems, especially in regard to the volatilization of the mineral constituents from coal, which gives rise to deposits from or corrosion by flue gases. Where research has suggested new engineering developments, the proof that the ideas may be made effective requires work on an engineering scale : this work may be carried out either at the Research Station at Leatherhead or in collaboration with Member-firms of the Association at works throughout the country.

To tackle these problems, mathematicians, physicists, physical and organic chemists, mechanical and chemical engineers are needed. The physicists must include specialists in infra-red and X-ray analysis and experts on heat transfer and fluid flow who can infuse a modern outlook into classical concepts. Problems which fall under the first two main headings, the physical and chemical, are investigated mainly by laboratory research teams which constitute the Basic Research Laboratories. Engineering problems are investigated by separate teams which carry out practical studies on boilers, producers, furnaces and domestic appliances; these teams constitute the Industrial and Domestic Development Laboratories. Where necessary, however, the departments in the basic research laboratories also carry out large scale work and field tests and the development departments carry out fundamental work. Each team usually contains

men with various types of training and includes junior personnel gaining experience in experimental work whilst continuing their studies, graduates taking higher degrees, and more senior men. In this way a fruitful interchange of experience results and the different trainings and diverse outlooks of the men in the teams can be amalgamated.

It is the responsibility of the scientific workers to apply their research results to practical needs, and they are frequently in contact with the industrial sponsors of the Association. This ensures that investigations are related to current problems in industry. At the same time the research men gain a wider outlook and equip themselves for fulfilling the purpose of the Association, this being not only to promote research and other scientific work in connexion with the utilization of coal and its derivatives, but to aid the application of this work in industry.

The main objects of the Association are to conserve coal, to diminish nuisance, to increase the efficiency and flexibility of coal utilization processes, and to develop more lucrative markets for coal products. To this end, the Association is supported by the four nationalized industries and by coal distributors, plant manufacturers, and coal consumers. It is a forum for the interchange of technical experience between national and private industry and this is, in itself, a contribution to the national economy.

One important problem concerns the minerals in coal. The availability of boilers is limited by the formation of deposits on high temperature surfaces and by the corrosion of cooler surfaces (economizers and air

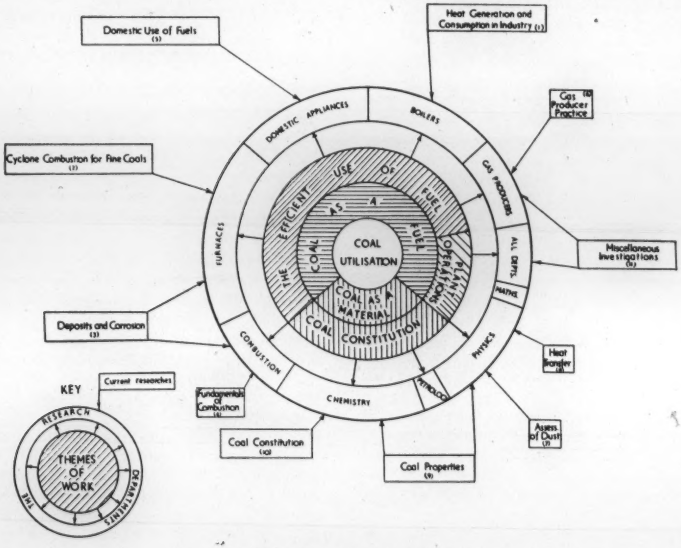

FIG. 2. *Pattern of current researches*

heaters.) Mineral deposits can accumulate in boiler systems to such an extent as to bridge the spaces between tubes, thus reducing heat transfer and the output and efficiency of the plant. It is then necessary to take the boiler off load and to clean it. Corrosion causes destruction in air heaters and necessitates frequent cleaning and renewal. These problems provide important illustrations of the need for combined laboratory, engineering and field work. In the laboratory attempts have been made to obtain a better understanding of the chemical mechanisms which underlie these troublesome phenomena. Corrosion arises mainly from the sulphur in the coal, which is converted to sulphur dioxide during combustion. A small fraction of the dioxide is further oxidized to sulphur trioxide which combines with water vapour to form acid. Traces of acid in the exhaust flue gases elevate the dewpoint and there is risk of corrosion when the gases are cooled below the dewpoint. This process has been investigated by means of a special instrument, the dewpoint meter. By noting the change in electrical conductivity when a film of condensate forms on a probe, a sensitive, indirect measure of acidity is obtained. More important than the actual dewpoint itself is the rate of condensation, which can also be assessed by the instrument. This rate is at a maximum for metal surface temperatures between 40 and 80°F less than the dewpoint.

The sulphur trioxide produced during combustion reacts with the volatile alkali chlorides to form alkali sulphates, bisulphates and pyrosulphates, which are molten or sticky over the temperature range encountered in superheaters. This leads to deposits on high temperature surfaces, which form a sticky film to which dust and ash particles adhere. Probes have been developed for the detailed study of deposition both in the laboratory and in the field. An investigation of the mechanism of adhesion by an X-ray scattering technique has suggested that there is an epitaxial relationship between a potassium aluminium sulphate phase and a haematite phase. In order to accelerate the accumulation of data, obtained under controlled conditions, both on corrosion by flue gas and deposition in boiler systems, a specially designed pulverized fuel furnace has been built at Leatherhead.

Early investigations of boiler availability were concerned with water-tube boilers at central power stations fired by mechanical stokers. With the application of the knowledge now gained and improved methods of cleaning, availability of these boilers is now much improved. Also with the increasing use of pulverized fuel firing the nature of the research problems has changed, for the presence of dust particles in the flue gases from pulverized fuel fired boilers appears to make them relatively immune from corrosion, probably by preferential absorption of acid. With the increasing use of coals of high chlorine content at new generating stations, however, the possibility of deposition and corrosion cannot be dismissed.

Notwithstanding the decade and a half of investigation in the B.C.U.R.A. and elsewhere much remains to be done to elucidate the underlying mechanisms of boiler availability. To this end the work of the chemist, physical chemist and engineer must be supplemented by that of the physicist. There is need for an adequate physical theory of the deposition of solids from gases ; the simple theory of thermal precipitation from slowly moving gases at low temperatures is not good enough. Also the physics of adhesion needs development in order to establish more precisely the relative importance of the many factors operating in large boilers.

A more immediate contribution by the physicist to this field of investigation is in the accurate measurement of the temperatures of flame and gas and of metal surfaces in a boiler. These measurements are needed for the better study of all types of coal-consuming equipment (Figure 3). Robust instruments, able to stand up to arduous conditions of field testing, need to be developed. The ordinary suction pyrometer is too easily blocked by ash particles in the flue gases : use of a refractory head of low conductivity as a radiation shield has proved beneficial (3 (a)). A pneumatic pyrometer for measuring very high temperatures has been built (3 (b)) :

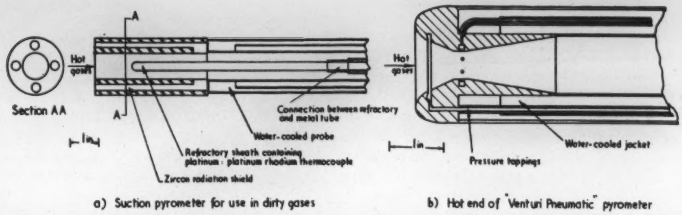

FIG. 3. *(a) Suction Pyrometer with refractory head ; (b) Pneumatic pyrometer (for measurement of temperatures of dirty gases)*

here the hot gas is passed through a venturi, is cooled and passed through a second venturi, where the temperature is measured, the hot gas temperature being found from the change in density between the two venturis. Venturi throats are less liable than are orifices to block or change their calibration.

Another development in the measurement of flame properties has arisen from investigations into the quality of producer gas and the effect of preheat on cracking the tar in the gas, a process which leads to deposition in gas mains and to changes in the luminosity of the gas flame. A gas evaluator (Figure 4) has been constructed in the belief that fundamental physical measurements made on the flames of actual gas samples drawn from producer gas plant will provide data for calculating the performance of furnaces.

Returning to minerals in coal, there has long been a need for their identification and estimation. Straightforward applications of X-ray techniques are complicated by the presence of organic material, which must first be removed by processes which do not change the mineralogical composition. Diffraction patterns can now be obtained using a specially designed X-ray diffractometer

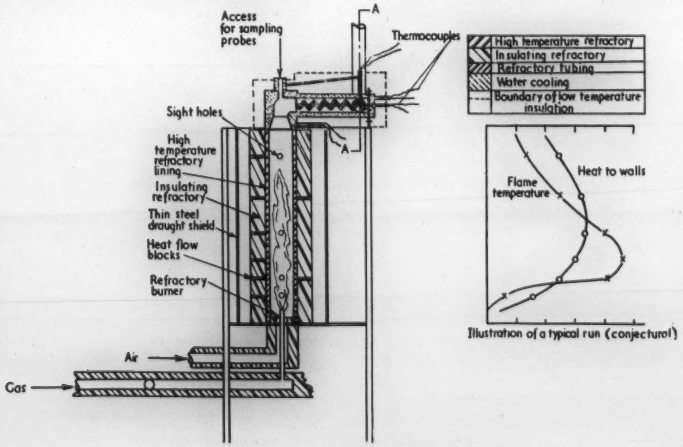

FIG. 4. *Evaluation of flames (for study of preheated producer gas)*

fitted with a Geiger counter for automatic recording of the intensity of the diffracted beam. By this means quartz clay minerals and carbonates in coal can now be determined.

Since deposits and corrosion are highly important factors affecting the use of fuel, both coal and oil, they have been discussed first. This holds true not only for boilers ; it is anticipated that gas turbine developments will run into difficulties in this field.

A new method of combustion is being developed in the Association. In the cyclone combustor granulated coal is fed in with the swirling gas. It burns in part whilst in suspension and then adheres to the walls of the cyclone (which are covered with molten slag) where combustion is completed. Approximately 90% of the ash left from the coal is removed by the flow of the slag down the walls of the cyclone.

Boilers used in industry consume about 60 million tons of coal annually. The Association has had to fill a gap in the pattern of knowledge by investigating the effects of coal quality on performance. A fully instrumented Economic boiler of 7,000 lbs. per hour evaporative capacity was used. Exhaustive measurements have been made to assess the influence of rank of coal, its size, moisture content, ash content and coking properties on efficiency and output. With a chain grate stoker, $\frac{1}{2}$–0″ boiler smalls of any rank can be burnt efficiently provided they contain surface moisture in the range 1–1$\frac{1}{2}$% for every 10% of coal below one-eighth inch mesh. There is serious loss of output and efficiency if fine coals are burnt dry. The effect of ash content is smaller, efficiency being reduced by about $\frac{1}{2}$% for every 1% increase in ash (somewhat more for coals containing large quantities of fine material). The simple explanation of the need for moisture conditioning of boiler smalls is that it leads to a more uniform and open fuel bed than is obtained with dry coal. Current research is directed to improvement in the design of stokers (Figure 5).

As off-shoots of this main programme, the deposition of grit and dust in boilers (known markedly to reduce heat transfer) has been alleviated by simple baffles which alter the flow of gases in the passes of the boiler. These baffles have the added advantage of mixing the gases fairly well and thus aid the completion of combustion in the gas phase.

In connexion with boiler trials it has been necessary to examine carefully the two ways of measuring efficiency, by coal and water

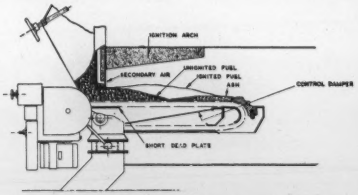

FIG. 5. *Combustion over a short chain-grate stoker (part of work for improving mechanical firing appliances.)*

balances and by difference, that is by measuring the losses and subtracting from 100%. Owing to difficulties in temperature measurement and in sampling gas for analysis, these measurements are fraught with large errors. A complete theory of the accuracy of boiler trials has been worked out : this involved the mathematical development of methods of combining errors, some being distributed according to the rectangular law and others the Gaussian law.

The need for improved designs of domestic appliances has been clearly stated in the

recent Ridley and Beaver Reports, in which special attention was given to the reduction of smoke emission with consequent improvement in efficiency, increase in comfort and conservation of fuel. In laboratory experiments on the emission of volatile constituents from coal during the early stages of its heating, measurements of ignition temperature have been made and the possibility of catalytic oxidation of the smoke has been studied. Mention may be made of the discovery that in reversed flames (in which air is burned in an envelope of volatile material) intermediates in the complex processes of polymerization can be collected and identified. Here—as in common experience—practical necessity has led to an advance in technique which has academic significance. As might be expected, gravimetric and optical measurements of smoke emission from domestic appliances do not agree, and to meet the needs of accurate research a tiny electrostatic precipitator has been developed which is able to collect the total emission from a domestic stack. It is now possible reliably to relate smoke emission to fuel type and to appliance design.

Domestic appliances, with their small fire beds working under natural draught, present peculiarly difficult problems of measurement of temperature and flow rates, and sensitive radiometer cages and anemometers have had to be developed. It is now common practice to put the whole installation on a weighing platform, which is designed to record automatically the rate of burning from moment to moment.

In the study of grit and dust emission the answers to two simple questions are needed. How much dust is there in a gas stream and what is its size distribution ? The former can be determined (Figure 6) by sampling the gases, provided due (statistical) account is taken of stratification and of fluctuations in dust burden due to changing conditions in the combustion equipment. A simple means of sampling is to place a small cyclone directly in the gas stream, thereby avoiding difficulties due to condensation when the gas is cooled. If constructed accurately, a reliable representative sample is obtained, and can be weighed for dust content. Size distribution has been measured by two methods. An automatic particle sizer and counter has been developed in collaboration with a Member-firm on principles deriving from a theory of line scanning. According to this theory, the

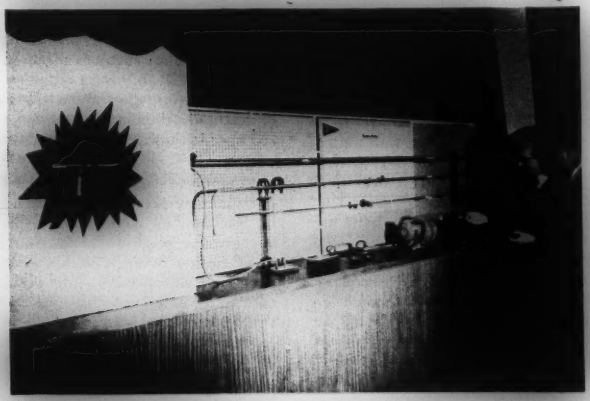

FIG. 6. *Cyclone probe for sampling dust in gases*

scanning of dust particles (dispersed on a microscope slide) by light beams differing in cross-section gives the size distribution. In the second method the size of the particles is determined by their free falling speed. This is found directly by serial removal of the fractions of dust thrown down on centrifuging the gas. Since a mass of particles collected in a thimble cannot be redispersed with any confidence into the form in which they existed in the gas, the further development of this method is desirable.

Behind all of the above practical investigations, there is the question — what is coal ? Many years ago coals were classified into four rock types—vitrain, clarain, durain and fusain—easily distinguished by eye. Examined under the microscope, these types are seen to be mixtures and a more fundamental classification into " organic minerals " called " macerals " has been proposed. By viewing under oil immersion, the different types show characteristic reflectances and a quantitative analysis of the petrological composition of coals is possible.

Coal is a mixture of chemical substances, which are themselves of complex molecular structure ; the study of the chemistry of coal thus presents major difficulties. Since many British coals consist largely of vitrain, most of the work has been simplified by separating out vitrain (as far as possible) for examination.

The molecular skeleton of coal probably consists of linked carbon atoms interlinked with each other and to some extent with part of the oxygen atoms present and to a minor extent with sulphur and nitrogen atoms. Attached to this main structure are hydrogen atoms, and hydroxyl and other groups. The skeleton can thus be visualized as built up of units, each consisting of a fairly compact cluster of atoms, a few of these cluster units being linked together, still by chemical bonds, to form the whole chemical molecule. The chemical molecules need not be all of the same size and in solution may tend to stick together by secondary forces to form physical aggregates. These aggregates differ from chemical molecules in that they are not fixed entities and may vary in size and shape according to the concentration of the solution and the solvents.

The range of molecular size is being studied by determinations on coal solutions of osmotic pressure, light scattering, diffusion coefficients, and other properties. This work has indicated molecular weights in the range 600–3,000 and also the presence of "colloidal" particles of quite large size. It appears from the evidence that strong aggregation takes place as the concentration of the solution is increased from 0.01% to 0.1%. A few preferred sizes of colloidal aggregates sometimes predominate.

Measurements of viscosity and of streaming birefringence show that large unsymmetrical rigid molecules are absent. Why and how the molecules so readily stick together to form aggregates is an important question for elucidation in the future.

Infra-red absorption spectra (Figure 7) indicate that a considerable proportion of the carbon in coal is aromatic in character and suggest therefore that the nuclei of the cluster units are platelets, consisting of hexagonal, benzene type rings. The average size of these nuclei, together with some idea of their relative disposition in three dimensions, has been deduced from X-ray scattering measurements. The carbon atoms in disordered groups surrounding the nucleus cannot be studied by X-ray methods ; but both X-ray measurements and infra-red spectra have furnished information about the proportion of the total carbon in these groups, and infra-red spectra have given indications of their nature.

Attempts to separate the dissolved material into different molecular types are being made by fractionating coal solutions, particularly by chromatography. So far, infra-red and other studies of the chromatographic fractions have shown them to be identical with each other and similar to the original coal. Differences have been observed in fluorescence spectra, but it is not yet known whether the fluorescence derives from a major or minor part of the material present in each fraction. It would appear that whatever the morphological differences, apparent even in pieces of

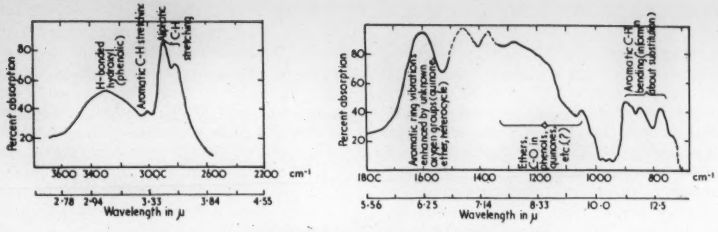
Percent absorption
H-bonded hydroxyl (phenolic)
Aromatic C-H stretching
Aliphatic C-H stretching
3600 3400 3000 2600 2200 cm⁻¹
2·78 2·94 3·33 3·84 4·55
Wavelength in μ
Aromatic ring vibration + hydrogen bonded oxygen groups (quinone, ether, heterocycle)
Ethers, C-O in phenols, quinones, etc. (?)
Aromatic C-H bending (elimination about substitution)
1800 1600 1400 1200 1000 800 cm⁻¹
5·56 6·25 7·14 8·33 10·0 12·5
Wavelength in μ

FIG. 7. *Typical infra-red absorption spectrum of coal.* (87·37°C.)

pure vitrain, the ageing process has reduced the material, chemically, very nearly to a common denominator.

As a result of work in the B.C.U.R.A. and parallel work elsewhere, a general picture of coal is now taking shape. In the vitrinite molecule, the aromatic nucleus probably contains between four and thirty fused hexagonal rings of carbon, the number depending on the rank (e.g. carbon content) of the coal. The nucleus is surrounded by a considerable amount of carbon and hydrogen in the form of short aliphatic side chains or saturated ring structure, the proportion of aliphatic to aromatic carbon ranging from about 1 : 2 down to 1 : 10, according to the rank of the coal. Lower rank coals contain perhaps 5% of the oxygen in the form of phenolic hydroxyl groups attached to the nucleus. This feature is absent from coking coals. There may also be up to 5% of oxygen in other forms, such as quinone groups, ether links and so on. Each molecule consists of only a few cluster units. It is believed that this picture is substantially correct although the details cannot be filled in as yet.

Quite recently a paramagnetic resonance peak has been found, the intensity of which increases rather sharply with increasing carbon content of the coal. This indicates the presence of unpaired electrons, probably associated with free radicals. The intensity of the peak changes on carbonization of the coal, increasing at first and then falling to zero at temperatures of the order of 700°C. This decrease is probably due to the appearance of conduction electrons.

Some evidence is forthcoming on the ultra-fine structure of coal from measurements on the adsorption of gases and vapours at a series of pressures and from the heat liberated when powdered coal is suddenly immersed in organic liquids such as methyl alcohol or butyl phthalate. These measurements, interpreted in terms of coal as a "molecular sieve," have given a fairly complete picture of the network of capillaries which runs through particles of coals. The evidence suggests that the internal passages in coals may be flat with only one dimension of critical size (of the order of 10 Å) interrupted by smaller constrictions. These characteristics are but little changed on carbonization until temperatures above 700°C are reached, when the constrictions rapidly tend to close up, but they may be re-opened by subsequent activation with steam.

Turning now to physical measurements of coal properties, it has been found possible to cut thin strips and shaped specimens of some coals, so that acoustical methods can be used for the determination of elastic moduli and internal friction (Figure 8). The technique allows the effects of temperature (even changes below 100°C are important) and environmental conditions, such as humidity, to be studied, The results obtained so far with strips of coal, present some unusual features ; for example, the internal friction appears to be dependent upon both amplitude of vibration and frequency. The

dependence upon amplitude increases markedly as the temperature of the specimen is increased above room temperature. For a full understanding of this work further theoretical developments will be necessary. The results obtained are perhaps not unexpected, since it is known from earlier work that as the particle size of a coal is decreased, plastic or viscous deformation becomes more important than the recoverable deformation noted with large pieces.

The above mentioned experiment is the successor of the first experiment referred to in this article, that is, the dropping of coal on to an iron plate. It is part of a general investigation of the pulverizing of coal. In the breakage of lump coal the system of micro-cracks or weaknesses permeating the mass has great importance, since these usually determine the places at which the material fractures. Usually fracture is accompanied by the production of large quantities of dust. In this connection an isolated experiment may be mentioned : repeated blows of very low intensity have been shown to lead primarily to partition of a lump into one or two pieces, and only later to disintegration with the production of dust. Insufficient is at present known to say whether or not this will find practical use. The physics of coal is only now beginning to enter a truly quantitative stage of investigation and it is anticipated that great advances will come in the near future.

At one end of the research spectrum are situated investigations at the boundaries of present academic knowledge (e.g. in paramagnetic resonance, dynamic adsorption of gases, vibration measurements, and the physics of combined flow of fluids and solids) and at the other end practical studies of the behaviour of actual coal-using plant. In between these extremes, development work is undertaken on an engineering scale and recently expanded physical and chemical knowledge is applied to long-standing problems of the coal-using industries. Of the latter it may be said that when one has seen what to do, it is obvious. But the training and experience needed to see what to do must not be too lightly discounted.

At the present time, the " emission lines of the spectrum " are : (1) deposits and corrosion in boilers, (2) improvements in methods of firing boilers, (3) improved design of domestic appliances, (4) evaluation of producer gas flames, (5) sampling and analysis of grit and dust, (6) fractionation of coal solutions and coal constitution. New main interests will probably include also (7) firing of locomotive boilers, (8) gas cleaning, (9) improvement of gas producers, and (10) identification of the coking flux in coals. Other developments, as yet unseen, may be expected to stem from current research.

The author's thanks are due to his colleagues whose work has been reviewed here.

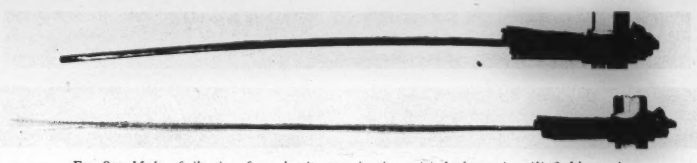

FIG. 8. *Modes of vibration of a coal strip approximating to (a) 1st harmonic ; (b) 2nd harmonic*

Reviews of Books

TECHNICAL EDUCATION : Its Aims, Organization and Future Development

By P. F. R. Venables, B.Sc., Ph.D., F.R.I.C.

London : G. Bell and Sons Ltd. Pp. xii + 645. Price 42s.

This is an important and timely book. Its author's impressive achievements at the Royal Technical College, Salford, are his sufficient authority to speak with vigour and to be heard with respect on a subject that has been endlessly and tiresomely discussed and pronounced upon for ten years, until utter nausea has overcome those who merely wish to see some constructive action ensue. This is not just another pontification to be added to the multitude of references that the well-read educational planner is expected to quote. It is essentially a detailed description of the numerous types of course that the various grades of technical institution are called upon to provide ; historical details and social, industrial and educational problems are introduced to shed light on this main theme.

Throughout the book statistics of the year 1952–3 are mainly used (although at least one reference is to a decision taken in June 1955) and, although this is the latest information that could be expected to be available, it may well be that some of Dr. Venables's deductions would be significantly different if based on later figures—as the Institute's recent report on the availability of places for physics students strongly suggests.

The first four chapters describe the types of technical institution, the courses they offer and the students they attract ; chapter V explains the complexity of the partnership, comprising industry, universities, government departments, local authorities, professional institutions and the college staffs, that constitutes the technical educational system. There are good references to sandwich courses, the problem of secondary technical education and the work of the Regional Councils. A somewhat rambling chapter on Industry and Education is followed by an excellent one on Selection in Technical Education, an excellence which overcame my personal suspicion of jugglings with quotients or scores purporting to measure fitness for a particular form of education.

Chapters VIII–XII have been contributed by specialist authors and cover Engineering (Mr. C. L. Old), Building (Mr. D. A. G. Reid), Art (Mr. K. Holmes), Women in Further Education (Miss E. Hollings) and Commerce (Dr. E. Thompson). On the whole these are very good but they inevitably introduce some overlap with what has appeared earlier.

The primarily factual and descriptive part of the book is completed by two chapters on Other Technologies and Crafts and The Sciences.

The inevitable disquisition upon Higher Technological Education follows as Chapter XV, an adequate if somewhat stodgy account. Most of the references and much of the history are given in their wearisome completeness and one need say no more. As though he felt that duty had now been done, Dr. Venables restores the diligent reader's flagging spirits with a sparkling chapter on Freedom and Governance, Finance and Administration, excellent stuff that was clearly a joy to him to write, and he rounds off with chapters on Students' Needs, Staffing, Buildings and his Conclusions.

This is no mean achievement. It displays wide knowledge, ripe judgement and deep pride in the fine record of technical education. There are remarkably extensive lists of references, two good indexes and useful appendices. All in all, no one could seriously examine the book and record less than a distinction mark.

Despite this, there are not a few blemishes. One fault of the book is that it is too long, partly because it is in places too discursive. For example, in this kind of book it seems unnecessary to introduce the sciences, as taught in technical colleges, by a statement of the scientific method and a reference to "Occam's Razor." Again, although the diagrams and tables are mostly useful and informative, some of them add almost nothing and a few are merely confusing or, to me, meaningless.

The worst blemish of the book, however, is the frequency with which the style becomes ragged and the English slipshod. It may be considered to be pedantic to refer to uses of words and phrases that would distress Sir Ernest Gowers, but these become cumulatively annoying. There are many sentences that are clumsy, some that are ambiguous and even one or two that defy analysis. The reader may decide for himself the appropriate category for this example (p. 518): "Not the impossible tasks of knowing everything, or of meeting everyone and discussing everything, of seeing all the best films and not missing any of the best things on radio and television, nor of travelling everywhere and reading all the latest books; rather though some part of at least some of these, and in other ways to acquire first rate standards and the power of critical judgement." Again, as a minor example, I doubt whether Dr. Venables meant "the cleaning of rooms and equipment is greatly hindered if not sometimes entirely neglected."

There are also some ponderous remarks upon the obvious; of these Miss Hollings contributes more than her fair share, one monumental example being "The bearing and rearing of children is still the most important of all jobs, for without it the race would perish . . ." What a wonderful thing education is!

These matters are unfortunate—especially in a book that refers to the importance of good English. It is to be hoped that the more obvious defects of style will be corrected in the second edition.

NORMAN CLARKE.

MODERN PHYSICS

By John C. Slater

New York, Toronto and London: McGraw Hill Book Co. Inc. Pp. xi + 332. Price 41s. 6d.

What is Modern Physics? Are those working experimentally or theoretically on friction or static electrification, for example, old-fashioned? I suppose most of us for convenience use the term to include those branches of physics for which a satisfactory treatment cannot be given without the methods and ideas of quantum mechanics or relativity. In this book, Professor Slater considers it to be practically synonymous with atomic and nuclear physics and he traces the development of this subject from the remarkable decade 1895–1905 to the present day, with a preliminary glance at nineteenth century ideas. The book is intended not only for physicists but also for the increasing number of engineers, metallurgists and chemists who need and wish to learn something of the present state of atomic physics in a wide sense.

This book is not a textbook of mathematical physics, but the ideas of mathematics are used freely, and the book is not a first text for beginners. For the serious physics undergraduate and the graduate in engineering, chemistry and mathematics, however, it is an admirable book, particularly valuable for giving a perspective of the whole subject. Throughout there are the marks of a distinguished physicist and an experienced teacher. Each chapter begins with a clear summary which contains signposts to the paths ahead. Where appropriate the historical approach is used. At the ends of the chapters there are excellent problems. An appendix contains suggestions for further reading, including more detailed texts which honours students of physics will need to study to supplement the treatment given by Slater. The standard textbooks will be studied with much greater understanding, however, after reading, or in conjunction with, the clear and balanced account given in the new book, which is recommended without reserve.

F. A. VICK.

PRINCIPLES AND APPLICATIONS OF PHYSICS

By Otto Bluh, D.Sc., F.Inst.P., in collaboration with J. D. Elder, A.B., A.M.

Edinburgh : Oliver and Boyd. Pp. 866. Price 45s.

This book is designed to provide an introduction to the subject and is written with the requirements of students who do not intend to specialize in Physics, but who need a comprehensive understanding of its principles in connection with their other studies, kept well in mind. Although the aim is to present the text in an introductory form, it is expected that the student will have " some elementary knowledge of physics, or at least a grounding in some other scientific discipline." The standard is well up to the Advanced level of the General Certificate of Education and in scope the book covers considerably more ground than is required by the existing syllabuses of the various examining bodies. The authors' aim is to " fill the gap between elementary and advanced specialized textbooks and to promote at an early stage of science education understanding of fundamental principles."

To achieve this object the authors have abandoned the conventional division of physics into the arbitrary groups Heat, Light, Sound, etc., and have divided the book of nearly 900 pages into the ten following sections : (1) Methods of Physics including standards, Measurements and a mathematical introduction ; (2) Mechanics ; (3) Forms of Energy, Heat, Electrical and Radiation ; (4) Fields of Force, Gravitational, Electrostatic, Electromagnetic and Electrodynamic ; (5) Oscillations and waves ; (6) Thermodynamics ; (7) Constitution of Matter ; (8) Corpuscles and Quanta ; (9) Constitution of the Atom, and (10) an interesting review of the scope and importance of the physical sciences.

The mathematical introduction includes some calculus, but a major part of the book does not require its use, also systematic use is made of M.K.S. units in addition to other systems.

It is a little difficult to foresee how a treatment of this nature and scope fits into our English School-University sequence. The introduction envisages its use in the curricula of American and Canadian Universities where " it should be useful to the student from the time of his intermediate or sophomore work up to the more detailed studies of a general or honours physics course," and it is said to contain ample material for a two-year course. I have no doubt that a student who had mastered its contents would be better equipped to commence our three-year Special Honours Courses than the average matriculant with Advanced Physics, and I think that with backing from specialized texts it could be a valuable asset in a course for Subsidiary Physics occupying one year.

Schoolmasters with whom I have discussed the book have approved in principle its treatment, but doubted if it could be possible to cover the whole text in the time available for study of Advanced Physics in a sixth form. At the same time I believe that any School or University teacher who reads this book will agree that a course based on the methods it adopts will provide a far better approach to an understanding of physics for a student not proposing to specialize in the subject than will the methods most generally used in this country, designed as they are primarily to meet the needs of the intending specialist.

Space does not allow detailed comment, but in general I find the text clear, easy to read, and offering some novel ways of introducing various aspects of the subject. I for one would be glad to know if others believe it to be possible to modify our curricula so as to make it possible to teach introductory physics on the lines adopted in this book, but I realize that it would be a very serious problem to find the time to do so. But if it is possible, I feel sure there would result a better understanding of the aims and possibilities of the scientific method than are at present possessed by the average student.

Sets of questions and numerical examples are not included in the text, but there are many good collections of these available in small convenient books.

S. H. Piper.

GENERAL PHYSICS

By Oswald Blackwood and William Kelly

New York : John Wiley & Sons Ltd.
London : Chapman and Hall Ltd. Pp. 704.
Price 54s.

Text books fall into two main classes: those which can be read with pleasure and which stimulate a student to study further in the subject and those which contain just bare factual knowledge. This book, written by two American university professors, is in the first category and its authors' claim " to present fundamental physics clearly and logically " is well substantiated.

In this second edition it is a most attractive book developing Physics as a vital science and presenting its topics through the use of the student's common knowledge and everyday experience in a typically forthright American manner. It is very well produced, the authors combining an excellent text, abundant illustrations, and clear diagrams with printing and binding of the standard we associate with the best American textbooks.

The contents of the book justify the title of General Physics for it covers the entire physical field from Archimedes to the Atomic Pile to a standard approximating to the "A" level of the General Certificate of Education; the sequence being Mechanics, Molecular Physics and Heat, Sound, Electricity and Magnetism, Light, and the New Physics. In some parts the treatment is more extensive reaching at times to Scholarship level and all the time there is the constant stimulation to the student to develop a sense of " Physical feeling."

The Mathematical content is well within the grasp of the average " O " Level candidate and the book would be an excellent basic work on Physics for the " Non-mathematical " type of Physics student who is reading Physics, Chemistry and Biology for entry to Medical or Dental courses. For the more serious student of Physics the deliberate avoidance of calculus methods could cause some irritation.

The examples at the end of each chapter make an excellent revision course, test a student's reasoning power and are very searching, but it is difficult to understand the authors' policy in giving answers only to the " odd-numbered " problems. The transatlantic flavour of some of these questions and of some of the text is interesting, often opening up quite new trains of ideas yet at no point deviating from what would be acceptable to an English examiner.

It is a pity that the very comprehensive little bibliographies at the end of each chapter do not contain more British books as students in this country would find most of the books mentioned very difficult to consult.

My only objection to the book is its price. I feel that very few Local Education Authorities would authorize its use as a class textbook. I would recommend it for inclusion in any School Library and it forms a particularly good " teacher's book."

W. B. CHIVERS.

AN ILLUSTRATED HISTORY OF SCIENCE

By F. Sherwood Taylor, M.A., B.Sc., Ph.D.

Illustrated by A. R. Thomson, R.A.

London : William Heinemann. Pp. xii + 178.
Price 25s.

The Royal Institution Christmas Lectures " adapted to a juvenile auditory," begun in 1826, have not only delighted generations of children fortunate enough to hear them delivered but have enriched the literature of science. There must be few physicists who do not recollect with great pleasure their first acquaintance with Faraday's *Chemical History of a Candle* (the lectures of 1860) or Sir William Bragg's *Concerning the Nature of Things* (1923). The present volume by Dr. Sherwood Taylor is based on the lectures of 1952 and is worthy to take its place with the best in this distinguished company. The writing has Dr. Taylor's characteristic sparkle and is well matched by the drawings of Mr. Thomson. They are an admirable team but it is right that due praise should also be recorded for the excellent contribution of the publishers. Publishers are much maligned, particularly

on matters of price, and it is a special pleasure to be able to commend Messrs. Heinemann for the exceptional quality of production of this book. Typography, paper and binding are of the highest class.

Parents, uncles and godparents need look no further for an assuredly successful present ; with luck and tact they might even be allowed to borrow the volume to read for themselves.

NORMAN CLARKE

GEOMETRICAL OPTICS

By L. C. Martin

London : Sir Isaac Pitman and Sons Ltd. Pp. 215 + vii. Price 22s. 6d.

This book is an introduction to the subject and covers largely the same ground as other textbooks. A closer study, however, shows that the treatment is markedly different ; the selection of topics and the way in which they are presented are evidently the result of long experience in the teaching of the subject. The treatment of sagittal and tangential rays in the very first chapter is an example of the realistic, rigorous approach and is in welcome contrast to the assumption, so often made in Optics teaching, that all rays conveniently lie in meridional planes which can then be identified with the plane of a diagram. The rigour and logical coherence which characterize the entire book may occasionally demand a certain effort on the part of the reader by forcing him to face genuine difficulties ; but the text is so clear and explicit that the book is nevertheless not hard to read.

There would have been some advantages in discussing the relations between wave optics and ray optics at the beginning of the book rather than in a later chapter, and in thus emphasizing the secondary nature and limited validity of the ray concept ; but this comment is offered as a statement of personal preference rather than as a negative criticism. In the chapter on Photometry, Lambert's Law is, as in most books, merely introduced as an empirical law. It would have been useful if its connection with the concept of equilibrium between a luminous surface and an isotropic radiation field had been introduced—this would have done more justice to the fundamental nature of the law.

The field of physics has become so large that the degree student can hardly be expected to acquire a very detailed knowledge of geometrical optics. Restriction without loss of essentials is difficult, and it is especially for this reason that this well-balanced, clearly written book will be warmly welcomed by teachers and students. It is to be hoped that it will be widely used and will thus help to raise the standard of the teaching of geometrical optics.

H. G. KUHN.

PHYSICS AND PHILOSOPHY

The first Robert Grosseteste Memorial Lecture.

By Lord Cherwell, F.R.S.

London : Oxford University Press. Pp. 21. Price 2s. 6d.

This lecture is to be welcomed as a shrewd and clear exposition of some of the notions introduced into physics by Special Relativity, by thermodynamics, and by the wave-particle duality of radiation. Compared with many popular accounts, the homely analogies employed here will be happily successful at touching-off response from the non-scientific.

The only thing to query is the title ; there does not seem any attempt at philosophizing, except a reiterated call that it would be desirable for physicists and " philosophers " to consider problems together without mutual contempt. " Introduction to some basic ideas of XXth century physics " might be a more appropriate heading, and under that mandate the lecture is of outstanding value.

The lack of any appeal to modern philosophy is emphasized by the very odd remark that metaphysics is what the author really means " since it is in this branch of philosophy that the contact (with science) should be closest." Wouldn't Lord Cherwell, on reflection, substitute " logic " or " theory of knowledge " for metaphysics ?

MARTIN JOHNSON.

Branch News

London and Home Counties Branch : 1955 " At Home "

On Friday, October 28, the London and Home Counties Branch held an At Home in the Institute's House. This was the third event of this nature held at the House, the previous occasions being in 1951 and 1953.

Over eighty Branch members and friends were present. Guests were greeted on arrival by Dr. J. S. Forrest (*Branch Chairman*) and Mrs. Forrest, and Dr. D. H. Follett (*Branch Vice-Chairman*) and Mrs. Follett, in the Board Room, which, for the occasion, had been transformed into a buffet lounge. Three performances of scientific films were given in the lecture theatre, whilst a most interesting display of colour photographs, made by various processes, was on view in the Members' Room. The photographs had been kindly lent for the evening by Kodak Ltd.

Left to right : Mr. B. S. Cooper, Mrs. Forrest, Dr. J. S. Forrest, Mrs. Follett, Dr. D. H. Follett

Various other rooms in the House normally in use as offices had been adapted as temporary laboratories in which various exhibits

Dr. K. A. G. Mendelssohn being welcomed by Dr. Forrest. In the background is Mr. W. G. Bird.

of scientific interest were on show throughout the evening. These included :—

The Flame Organ (*Science Museum*).
An experiment of John Tyndall (*Professor A. M. Taylor*).
An infra-red viewer (*Kodak Ltd.*).
Fluorescence ; Semi-conductors (*Research Laboratories, The General Electric Co. Ltd.*).
High voltage demonstration ; Reaction time test (*Central Electricity Research Laboratories*).
Magnetic tape recorder (*Research Department, British Broadcasting Corporation*).

As on former occasions, members of the Branch are extremely indebted to all those who helped with the exhibits and demonstrations, and to the staff who cheerfully suffered considerable inconvenience in order that the London Branch At Home should be a success.

B. S. Cooper.

Midland Branch

Professor P. B. Moon has succeeded Dr. W. Betteridge as Chairman, with a seat on the Board.

South Wales Branch

An important one-day conference has been arranged for April 13, at the University College, Cardiff. It is hoped that it will be of wide interest to industrialists as well as to professional physicists. During the morning and afternoon lectures will be given by Professor A. Porter (" The application of computers in the control of processes "), Mr. J. L. Putman (" Radioisotope techniques in industry and applied research "), and Mr. A. Whitaker (" Physical properties of coal "). In the evening Sir John Cockcroft will give a public lecture on " The future of science and technology in industry."

Admission to the conference will be by ticket and non-members of the Institute will be required to pay a conference fee of one guinea. Full details will be circulated shortly to members of the South Wales Branch ; other members of the Institute who would like to have details should apply to the Deputy Secretary of the Institute.

Yorkshire Branch

Professor W. Sucksmith is now Chairman in succession to Professor E. C. Stoner. He becomes a member of the Board.

News of Members

FELLOWS

G. L. J. Bailey has been appointed Superintendent of the Platinum Metals Research Laboratory of The Mond Nickel Company Ltd., London.

F. S. Barton is now an Adviser, Defence Supplies (Ministry of Supply), United Kingdom High Commissioner's Officer, Ottawa, Canada.

G. F. J. Garlick has been appointed Professor of Physics in the University of Hull.

S. K. Runcorn has been appointed Professor of Physics in King's College, Newcastle-upon-Tyne, University of Durham.

J. R. Whitehead is now a Director of RCA Victor Company Ltd., Montreal, Canada.

ASSOCIATES

R. E. Burnett is now Deputy General Manager of Marconi Instruments Ltd., St. Albans.

E. J. Burge has been appointed Lecturer in Physics at Woolwich Polytechnic, London.

P. Cowlin has taken up an appointment with Bailey Meters and Controls Ltd., Croydon, as a Senior Electronics Development Engineer.

R. D. Fortune is now working in the European Organization for Nuclear Research, Geneva.

P. G. Gane has taken up an appointment with the Anglo-American Corporation of South Africa, Ltd., Johannesburg.

J. W. Humphries is now a Senior Technical Officer with the Commonwealth Scientific and Industrial Research Organization, Sydney, Australia.

G. S. Parry has been appointed Lecturer in the Chemical Physics of Solids, Imperial College of Science and Technology, London.

A. G. Peacock has been elected Chairman of the Electrical and Electronics Section of the Scientific Instrument Manufacturers' Association.

Lt.-Col. G. D. Pegler is now in command of Electronics Wing, Maintenance Technique Development Establishment, Radar Research Establishment, Malvern.

E. Stanley has been appointed Lecturer in the Physics Department of Manchester College of Technology.

A. M. Squire is now employed as a Senior Engineer with the English Electric Company Ltd., Luton.

R. J. Wakelin has been appointed Group Leader, Atomic Weapons Research Establishment, Aldermaston, Berks.

R. M. J. Withers is now Control Engineer with the British Sugar Corporation Ltd., Peterborough.

G. B. Woffinden has taken up an appointment with the United Kingdom Atomic Energy Authority, Caithness, as an Assistant Group Manager.

GRADUATES

T. Ashton is now working in the High Energy Radiation Centre of Cookridge Hospital, Leeds.

K. J. Close has joined the staff of Nottingham and District Technical College as a Lecturer in Physics.

J. C. Cook is now a Scientific Officer at the Admiralty Research Laboratories, Teddington.

A. Gray has been appointed Technical Service Officer with Imperial Chemical Industries of Australia and New Zealand, Australia.

M. B. Lambie has taken up an appointment in the Department of Physics of the Imperial College of Science and Technology, London.

D. Rowan is now with the Western Regional Hospital Board, Glasgow, as a Physicist.

J. Sawkill has recently taken up an appointment as a Research Scientist, with Tube Investment Research Laboratories, Hinxton Hall, Nr. Cambridge.

J. F. Sayers is now employed by Electric and Musical Industries Engineering Development Ltd., Feltham, Middx.

M. Van Ments is a Studio Assistant with the British Broadcasting Corporation.

Forthcoming Institute Meetings

Jan. 11 London and Home Counties Branch — At the Institute's House, 6.30 p.m.
" *Modern Methods of Geophysical Prospecting for Oil* "
(Two short films will be shown)
DR. D. T. GERMAIN-JONES, F.INST.P.

Jan. 11 Yorkshire Branch — At the University of Leeds, 3.00 p.m.
" *The use of a Digital Computor in an Industrial Problem — namely Drying* "
PROFESSOR A. H. NISSAN

Jan. 13 Manchester and District Branch — At the University of Manchester, 6.45 p.m.
" *Physics and Engineering* "
DR. R. W. SILLARS, F.INST.P.

Jan. 13 Liverpool and North Wales Branch — At the University of Liverpool, 7.00 p.m.
" *Physics in Oceanography* "
PROFESSOR K. F. BOWDEN, F.INST.P.

Jan. 13 Non-Destructive Testing Group — At the Institute's House, 6.30 p.m.
Symposium :
" *The possible uses of Surface Methods as a means of testing metals* "
PROFESSOR S. TOLANSKY, F.INST.P., F.R.S.
DR. R. W. B. STEPHENS, F.INST.P., DR. O. S. HEAVENS, A.INST.P.

Jan. 17 Electronics Group — At the Institute's House, 5.30 p.m.
" *Modern Microwave Generation* "
DR. H. MOTZ, F.INST.P.

Jan. 17 North Eastern Branch — At King's College, Newcastle-upon-Tyne, 6.15 p.m.
" *Some Recent Work in Instrumentation and Optics* "
MR. G. M. SISSON

Jan. 23 Education Group — At the Institute's House, 6.00 p.m.
" *The Availability of Places for Physics Students in Universities and Technical Colleges* "
A discussion based on the Institute's recent report
MR. N. CLARKE, F.INST.P., and DR. J. TOPPING, F.INST.P.

Jan. 24 Midland Branch — At the College of Technology, Birmingham, 7.00 p.m.
" *The Friction and Lubrication of Solids* "
DR. ANITA BAILEY

Jan. 30 Scottish Branch At the University of Edinburgh, 7.15 p.m.
"*An Introduction to the History and Application of Computing Machines*"
DR. B. V. BOWDEN

Jan. 31 Scottish Branch At the University of Glasgow, 7.15 p.m.
"*An Introduction to the History and Application of Computing Machines*"
DR. B. V. BOWDEN

Feb. 1 London and Home Counties Branch At the Institute's House, 6.30 p.m.
"*The work of the National Bureau of Standards, Washington*"
DR. W. R. BRODE

Feb. 9 Liverpool and North Wales Branch At the University College, Bangor, 5.45 p.m.
"*The Magnetic Properties of Small Particles*"
PROFESSOR W. SUCKSMITH, F.INST.P., F.R.S.

Feb. 10 Manchester and District Branch At the University of Manchester, 6.30 p.m.
BRANCH ANNUAL GENERAL MEETING
followed at 7 p.m. by
"*Investigating the Structure of the Nucleus*"
PROFESSOR S. DEVONS, F.R.S.

Feb. 10 Non-Destructive Testing Group At the Institute's House, 6.30 p.m.
"*Interpretation of the Photographic Behaviour of the direct and X-ray screen image*"
DR. R. H. HERZ, F.INST.P.

Feb. 10 South Wales Branch At the University College, Cardiff, 5.15 p.m.
"*Radioactivity in Man and his Environment*"
PROFESSOR F. W. SPIERS

Feb. 14 Electronics Group At the Institute's House, 5.30 p.m.
"*Germanium and Silicon Crystals and Devices*"
DR. E. BILLIG

Feb. 15 London and Home Counties Branch At the Institute's House, 6.30 p.m.
"*Explosions*"
DR. STEWART PATERSON
preceded by
BRANCH ANNUAL GENERAL MEETING

Feb. 15 Midland Branch At the University of Birmingham, 5.15 p.m.
"*Colour*"
PROFESSOR W. D. WRIGHT

Vol. 7, January, 1956

The Institute's Journals

PRINCIPAL CONTENTS OF THE JANUARY, 1956, ISSUES

Journal of Scientific Instruments: Volume 33, No. 1

PAPERS

A scintillation counter for the assay of radioactive gases. By D. R. Stranks, (*University of Leeds*).

A glass chamber, with a plastic scintillator serving as one wall, may be used to assay gaseous samples of weak β-emitting nuclides (notably ^{14}C). The specific activities of duplicate samples can be reproduced to ±0·5%. Since the observed counting rate of an active gas sample is independent of gross impurities and the chemical form of the nuclide, sample preparation is simpler and faster than for other gas-counting methods. The scintillation counter assembly can be readily adapted to the assay of both liquid and solid samples ; the method described for liquid assays has certain advantages over existing methods.

Some aspects in the design of a torque magnetometer. By F. W. Harrison, Grad.Inst.P. (*Mullard Research Laboratories*).

The magneto-torsional system of a torque magnetometer is shown to be unstable if the torsion constant of the suspending wire is not chosen correctly. The way in which this fact limits the sensitivity of the apparatus is indicated.

A servo-mechanism for the study of self-extinction of gaseous discharges in cavities in dielectrics. By E. C. Rogers, Grad.Inst.P., E. B. Page, and V. G. Harriss (*British Insulated Callender's Cables Ltd.*).

A servo-mechanism is described which automatically measures and records the extinction voltage of discharges that occur in gas-filled cavities in dielectric samples subjected to 50 c/s alternating stresses. The discharges are detected by an electronic system, which operates an electromechanical unit controlling the testing voltage applied to the sample. This testing voltage is normally set at about four to five times the initial discharge inception value. At regular intervals, the servo-mechanism reduces the testing voltage until extinction of discharges occurs, and then returns it to the previous value. A continuous record of the testing voltage presents the variation of discharge extinction voltage with time in an easily assimilated form, thus providing a convenient method of studying self-extinction phenomena. An example is given of an extinction voltage/time curve plotted by the machine for a polyvinyl chloride sample containing an artificial cavity.

Some parasitic deflexions in parallel spring movements. By Prof. R. V. Jones, C.B., C.B.E., F.Inst.P., and I. R. Young, Grad.Inst.P. (*University of Aberdeen*).

This paper analyses some parasitic departures from parallel and rectillinear movement in simple and compound assemblies. The following factors are considered : accuracy of construction, geometrical proportions, spring variations, spring distortion, platform bending, clamp distortion, and gravity effects. It is shown that the " ideal " height at which to drive a parallel spring element is at half the spring height, and it is concluded that while spring tolerances are surprisingly " easy " care must be taken with the platforms and clamps if the highest performances are to be achieved.
In compound movements, the possibility of " slaving " the intermediate platform, suggested by Plainevaux, has been tested in practice with good results.

The stability of thermistors. By A. Beck, A.Inst.P. (*Australian National University, Canberra*).

Although thermistors may reach a state where their constants remain stable, they may later undergo a change which takes place in an arbitrary manner. It is still possible within certain limits, to obtain relative temperatures accurate to within 0·02°C.

A mechanical binary-decimal converter. By M. Setterwall (*Research Institute of National Defence, Stockholm*).

A simple and reliable mechanical device is described which is able to convert a number N from binary to decimal form. Details are given of a ten-digit converter, capable of exact conversion of numbers up

to 1,023. By using this in two steps, numbers up to $2^{20} \simeq 10^6$ can be converted with a relative accuracy better than $1/\sqrt{N}$.

The use of polarized light for the measurement of small angular displacements. By A. J. Bartley (*University of Durham*).

An investigation has been carried out into the use of polarized light for the measurement of small angular displacements of the order of one minute of arc. The basic technique is explained in detail and a description is given of a test rig which was built to determine the sensitivity of the method. The suitability of the system for dynamic measurements is discussed and various recommendations are made regarding possible future developments.

A laboratory scale chill-casting vacuum induction furnace. By D. A. Craw and W. G. Henry (*National Research Council, Ottawa*).

The details of the construction and operation of a simple laboratory scale induction furnace with a capacity of approximately 3 cm³, which may be used at either low pressures (10-4mm of mercury) or with an inert atmosphere is described. The furnace and induction unit are fitted to a tilting frame allowing the melt to be cast into a copper mould. Copper, silver, gold, magnesium and cadmium based alloys have been cast successfully with this apparatus.

Apparatus for the electronic presentation of optical diffraction patterns. By A. W. Hanson, A.Inst.P., and A. Menarry, Grad.Inst.P. (*College of Technology, University of Manchester*).

Apparatus has been built for the rapid visual presentation of small, rather faint optical diffraction patterns. An image of the diffraction pattern is focused on the photomosaic of a television camera tube capable of accumulating, for a period of about ten seconds, a corresponding charge pattern. This pattern is transferred to a storage device where it remains for a relatively long time during which it can be continuously presented on a television receiver. Examples of stored diffraction patterns are given.

A constant temperature solubility cell or reaction vessel for a Beckman quartz spectrophotometer. By D. N. Glew and R. E. Robertson (*National Research Council, Ottawa*).

An adaptor is described which permits the use of the Beckman D.U. spectrophotometer for the continuous study of equilibria and reaction kinetics in solution. The design permits the optical density measurement at closely controlled temperatures, while retaining simplicity of assembly and operation.

A wide range Schlieren system. By H. Jeffree (*Vickers-Armstrongs (Aircraft) Ltd.*).

The Schlieren optical system is well known to be a simple and sensitive method of displaying variations in air density, such as are found, for instance, in the flow of air through a wind tunnel. Normally, a choice must be made between high sensitivity to show fine detail and long range so that main features are not lost or distorted. Methods are given here whereby both high sensitivity and fine detail are obtained simultaneously. It is even possible to obtain unambiguous measurements through glass windows not initially designed for Schlieren work ; or to show find striations in all parts of a sheet of glass which has also larger surface irregularities.

Laboratory and Workshop Notes

A simple desorption system for obtaining temperatures above that of liquid helium.
By A. C. Rose-Innes *and* R. F. Broom.

A two-way tap for continuous operation.
By F. A. Grimes.

A thyratron index and time-marking unit.
By R. B. Morrison.

A method of preparing laminated copper.
By K. Nelson.

A simple relay-operated timer.
By L. R. Jenkin.

A magnetically operated vacuum valve.
By R. M. Glaister.

An object holder for microscopic measurements.
By H. Shapiro.

An adaptable mechanism for converting rotary motion into a succession of linear movements.
By A. L. Sims.

Correspondence

Transit time spread in electron multipliers.
From T. D. S. Hamilton *and* G. T. Wright.

A capacitance-resistance hygrometer.
From C. L. Cutting, A. C. Jason *and* J. L. Wood.

British Journal of Applied Physics: Volume 7, No. 1

CONFERENCE REPORT

Summarized proceedings of a conference on stress analysis, Sheffield, September, 1955.

By H. Spooner, A.Inst.P. (*Rolls-Royce Ltd.*).

The Ninth Annual Conference of the Stress Analysis Group of The Institute of Physics was held in the Stephenson Hall of the University of Sheffield on September 28–30, 1955. Papers dealing, amongst other things, with design, plastic yielding, work at T.N.O. Delft, aircraft engine vibration, and photo-elastic investigations, were read, and are summarized in this report.

PAPERS

Specimen thickness and image resolution in electron microscopy.

By V. E. Cosslett, F.Inst.P. (*University of Cambridge*).

The working rule that the resolution obtainable in the electron image of a biological specimen is of the order of one-tenth its thickness is quantitatively explained in terms of the energy loss of electrons scattered in the specimen and of the chromatic aberration of the objective lens. This limitation holds true down to the thinnest sections (100–200Å) that can be cut at present. That they normally do not show a resolution approaching 20Å is ascribed to lack of contrast. The use of a filter lens, rejecting all electrons that lose more than 10V, would improve both contrast and resolution. Its use is even more important for rendering visible carbonaceous structures of size comparable with the instrumental resolving power. A lower accelerating voltage than currently used for electron microscopy is desirable for specimens of poor contrast.

The analysis of gases at low pressures.

By M. A. Cayless, A.Inst.P. (*The British Thomson-Houston Co. Ltd.*).

An apparatus for handling and analysing small quantities of gas at low pressures is described. To avoid contamination an all-glass construction is employed and manipulation is entirely over mercury. Gases and gas mixtures may be readily introduced into experimental vacuum devices in measured quantities of 1μcm^3 and over at pressures as low as 10^{-6}mm of mercury. Evolved gases may be analysed at pressures between 10^{-3} and 1mm of mercury using mainly physical properties such as vapour pressure, diffusion and absorption for identification and separation. Normally an accuracy of about 2% of the total quantity is obtained when 5μl. or more is available. A method is described of identifying much smaller quantities in certain circumstances.

A study of the Formvar replica process.

By A. W. Agar, A.Inst.P., and R. S. M. Revell, A.Inst.P. (*Metropolitan-Vickers Electrical Co. Ltd.*).

A detailed study has been made of Formvar replicas of various depths of structure. Plain replicas, shadowed replicas and replicas shadowed on the back surface were prepared from each specimen and identical areas were photographed in the electron microscope. An interferometer microscope was used to measure the depths of structure on the metal specimens and on the back surfaces of the replicas. A reconstruction has thus been obtained of the shape of the replica cross-section under various conditions.

As a result of this work, it is concluded that an approximately true negative replica of the surface is only formed in the rare cases, when the thickness of the film is more than double the depth of the structure. In spite of this, however, the Formvar replica is suitable for many classes of work and precautions can be taken to offset its deficiencies.

An explanation is given for the varied published estimates of plastic replica resolution, and the resolution under standard conditions is estimated.

Caesium 137 for industrial radiography.

By R. S. Morgan, A.Inst.P. (*Armament Research and Development Establishment*).

The suitability of caesium 137 as a γ-ray emitter for the radiography of steel has been investigated. An exposure chart has been produced and penetrameter-sensitivities calculated from experimentally determined broad-beam and narrow-beam absorption curves. The broad-beam curve is approximately linear for steel thicknesses exceeding 0·8 in., and from its slope, it would be expected that caesium 137 would give radiographs similar in contrast to an X-ray tube operating at about 1·25 million volts peak. While caesium 137 is a useful source for the examination of steel in the thickness range 1·5 to 4·0 in., below 1·5 in., iridium 192 is superior. Within the range 1·5 to 3·0 in. the penetrameter sensitivity obtainable with caesium 137 reaches its optimum value and is better than that obtainable with either iridium 192 or cobalt 60. Protection data for sources of various strengths have been calculated from an experimentally determined attentuation-curve for lead.

The automatic recording of electron diffraction patterns applied to the study of evaporated copper layers.

By R. B. Kehoe, R. C. Newman, and D. W. Pashley, A.Inst.P. (*Imperial College of Science and Technology*).

An apparatus has been constructed which successively records complete electron diffraction patterns after preset time intervals. This has been used in conjunction with a reflexion specimen furnace of new design in the study of the growth of copper evaporated on to flat (111) silver surfaces.

Electrode deterioration in " keep-alive " discharges in transmit-receive switches. By D. Walsh, A.Inst.P., A. W. Bright, and T. J. Bridges (*Services Electronic Research Laboratory*).

An investigation of the behaviour of electrode materials in a discharge containing water vapour is described. Most common stable metals, as well as a semiconducting ceramic were tried. Some information is given on the increase of maintaining voltage and sputtering with time for both normal and abnormal glow discharges. Measurements of the rate of clean-up of water vapour in normal discharges have also been made.

A microwave resonant cavity method for measuring the resistivity of semi-conducting materials. By J. G. Linhart, I. M. Templeton, and R. Dunsmuir (*The British Thomson-Houston Co. Ltd.*).

A method is described for measuring the resistivity of semi-conductors at centimetre wavelengths. A small spherical or cubic specimen is placed in a cavity resonating in the H_{011} mode, and the reduction in Q due to eddy-current loss in the specimen is measured. The theory given enables the resistivity of the material to be calculated. It is shown that resistivities in the range 0·005 to 10 Ωcm can be determined.

The corona resisting property of polytetrafluorethylene. By K. Sugita, S. Nagao and Y. Toriyama (*Tohoku University, Japan*).

The existence of pin-holes in the granular structure of polytetrafluorethylene tape (0·055mm) is confirmed by microscopic examination. It was also shown by dielectric strength tests that the heat treatment to close these holes at about the transition temperature increases the mean breakdown voltage by some 20%, and reduces the spread in breakdown values from about 50% with untreated tape to about 20% with heat-treated tape.